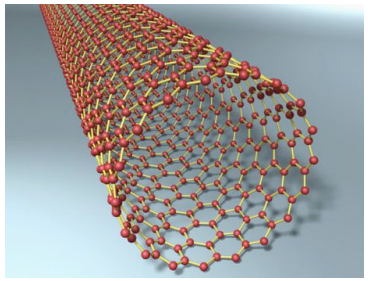
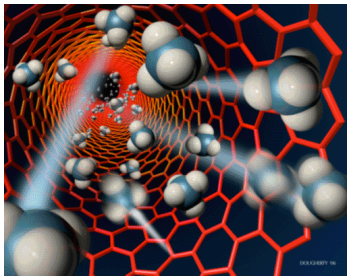
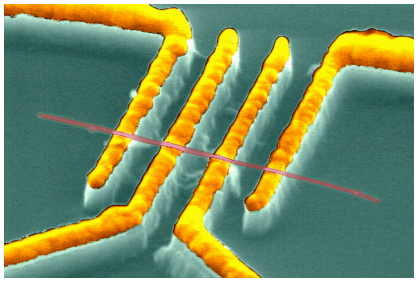
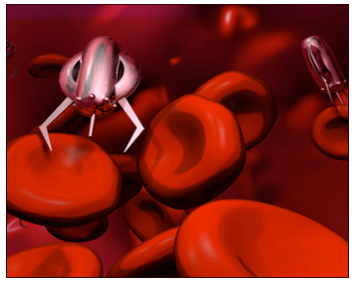
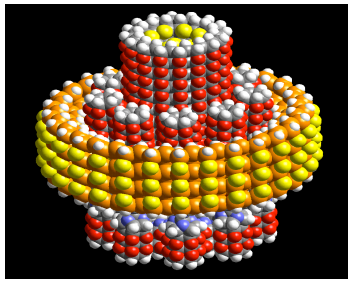
Nanotechnology

Tiny Science: Big Ideas

Maria C. Simani, Ph.D.

UCR - ALPHA Center

maria.simani@ucr.edu

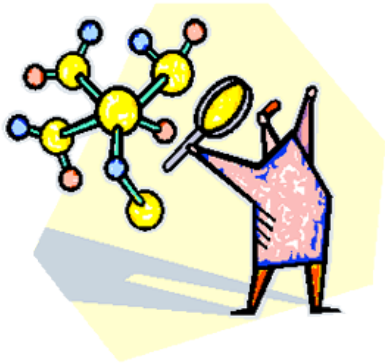
1. What is nanotechnology?
2. What is the big deal about nanotechnology?
3. Which skills are needed to work at the nano-*scale*?

What is nanotechnology?

1 nanometer = 1/100,000,000 of a meter
(one billionth of a meter, or 10^{-9} meters)

Nanotechnology is …

- An emerging, interdisciplinary science involving **mathematics**, physics, chemistry, biology, engineering, etc.;



- A way to study, control and manipulate matter at the atomic scale (nano-scale);

- An *enabling technology* with impacts on electronics, computing, medicine, energy, environment, and much more!

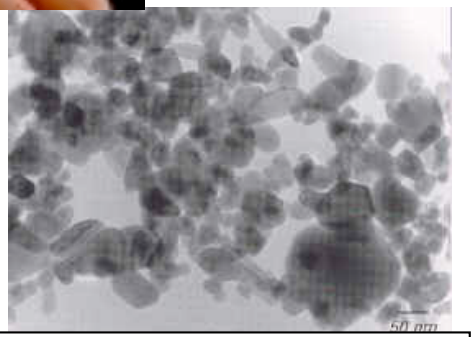
Nanotechnology on Your Skin

- In sunscreen ZnO particles is the agent blocking UV lights.
- Large ZnO particles
  - Scatter visible light, so appear white
- Nanosized ZnO particles
  - So small compared to the wavelength of visible light that they don't scatter it, so appear clear.

"Traditional" ZnO sunscreen is white

Nanoscale ZnO sunscreen is clear

More than 200 patents for products containing nanocompounds



Zinc oxide nanoparticles

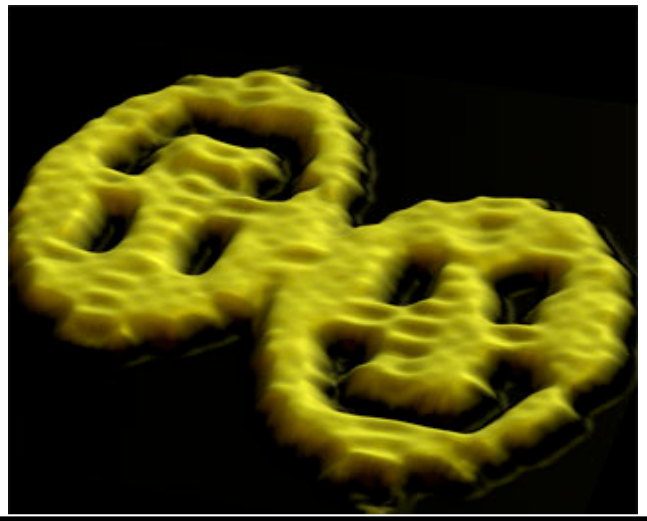
Nanotechnology is the technology of the 21st Century

- By 2015 Nanotech could create as many as 3M jobs in the US
[Int. Ass. of Nanotech, 2008]

- Economists predict a $1.5 trillion dollars global multi-industry market for nanotech in the next 10 years
[this is where you want to invest!]

- The world is changing and our ability to succeed in the new world depends on our ability to adapt to new situations and learn quickly.
[Transfer acquired knowledge to new contexts]

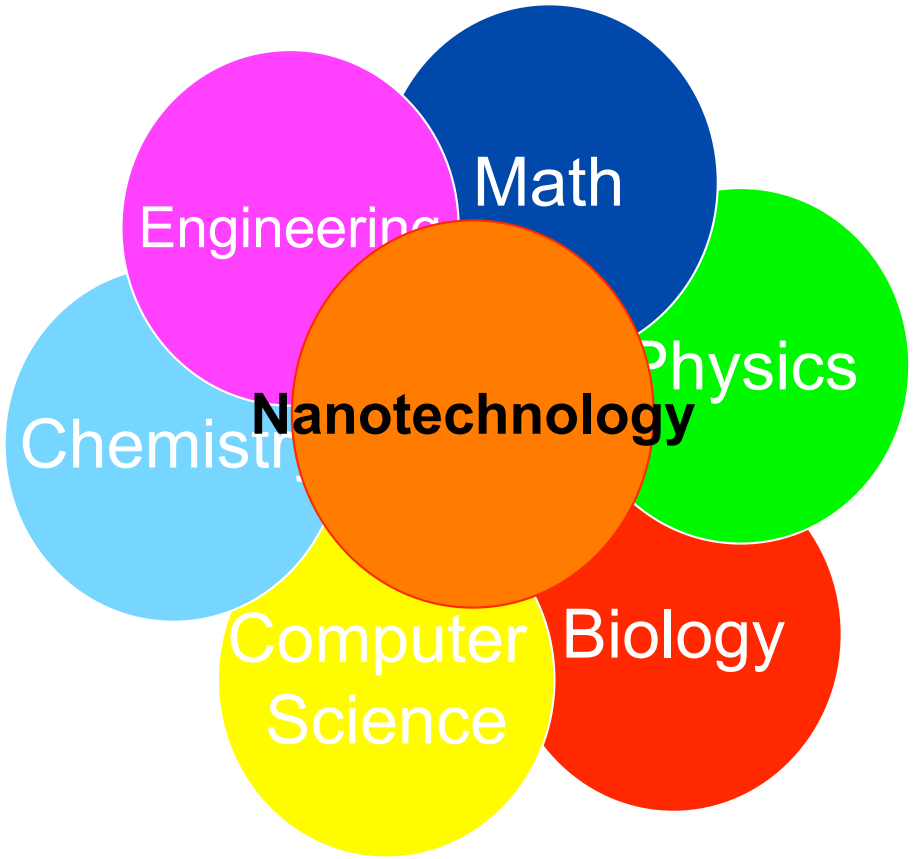
Need to develop nanotech interest and skills for the future workforce *NOW*



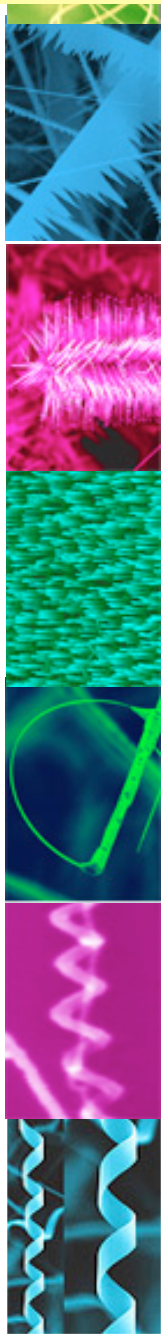
DNA Origami by Paul Rothemund

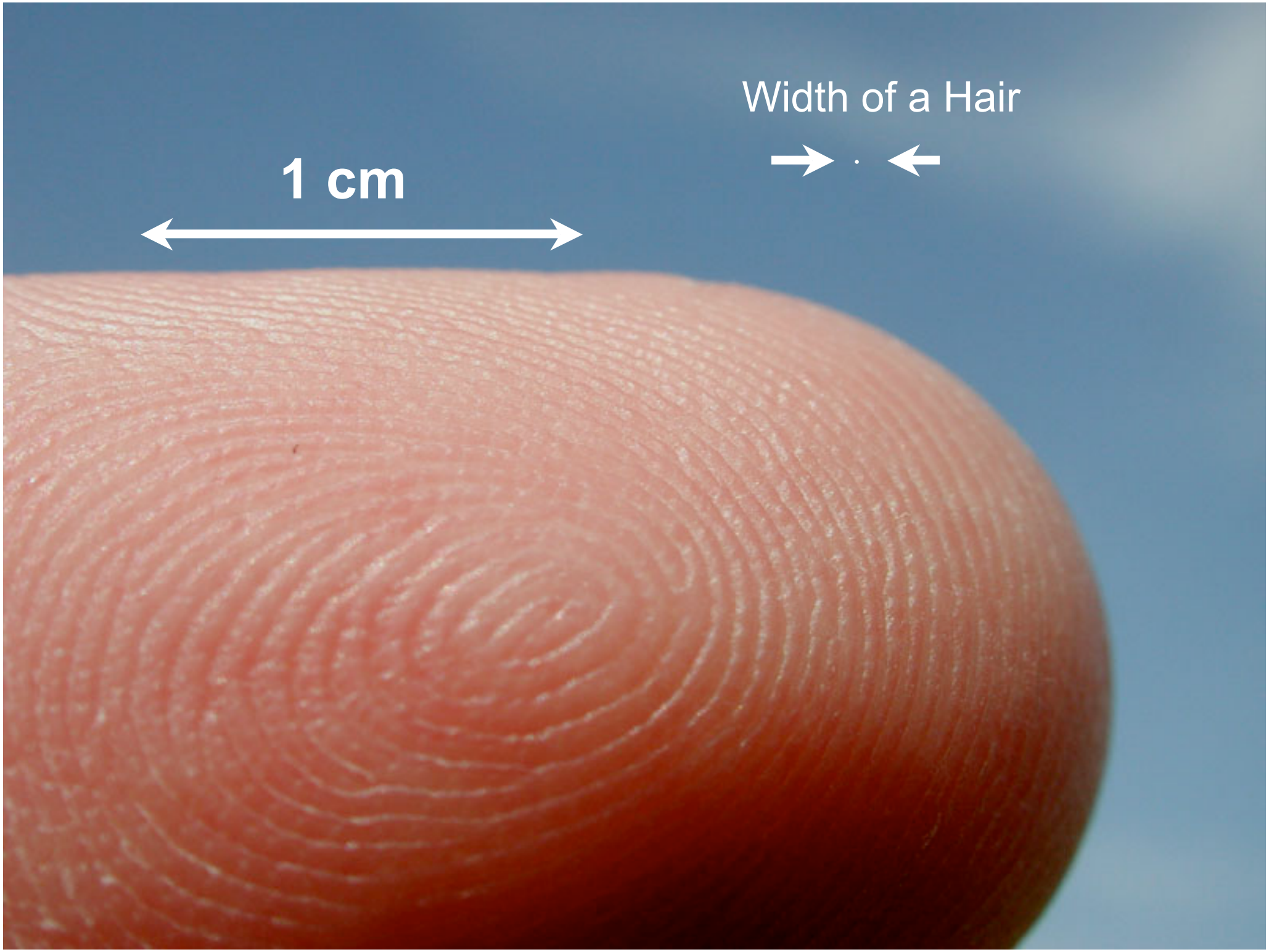
Interdisciplinary Nanotechnology

- Core concepts identified by the Advancing Nanoscience Education Group (2008):
  - Scale/Size (linear vs surface vs volume)
  - Relation between structures and physical properties
  - Control of fabrication/manipulation and self-assembly
  - Curiosity and creativity!!!

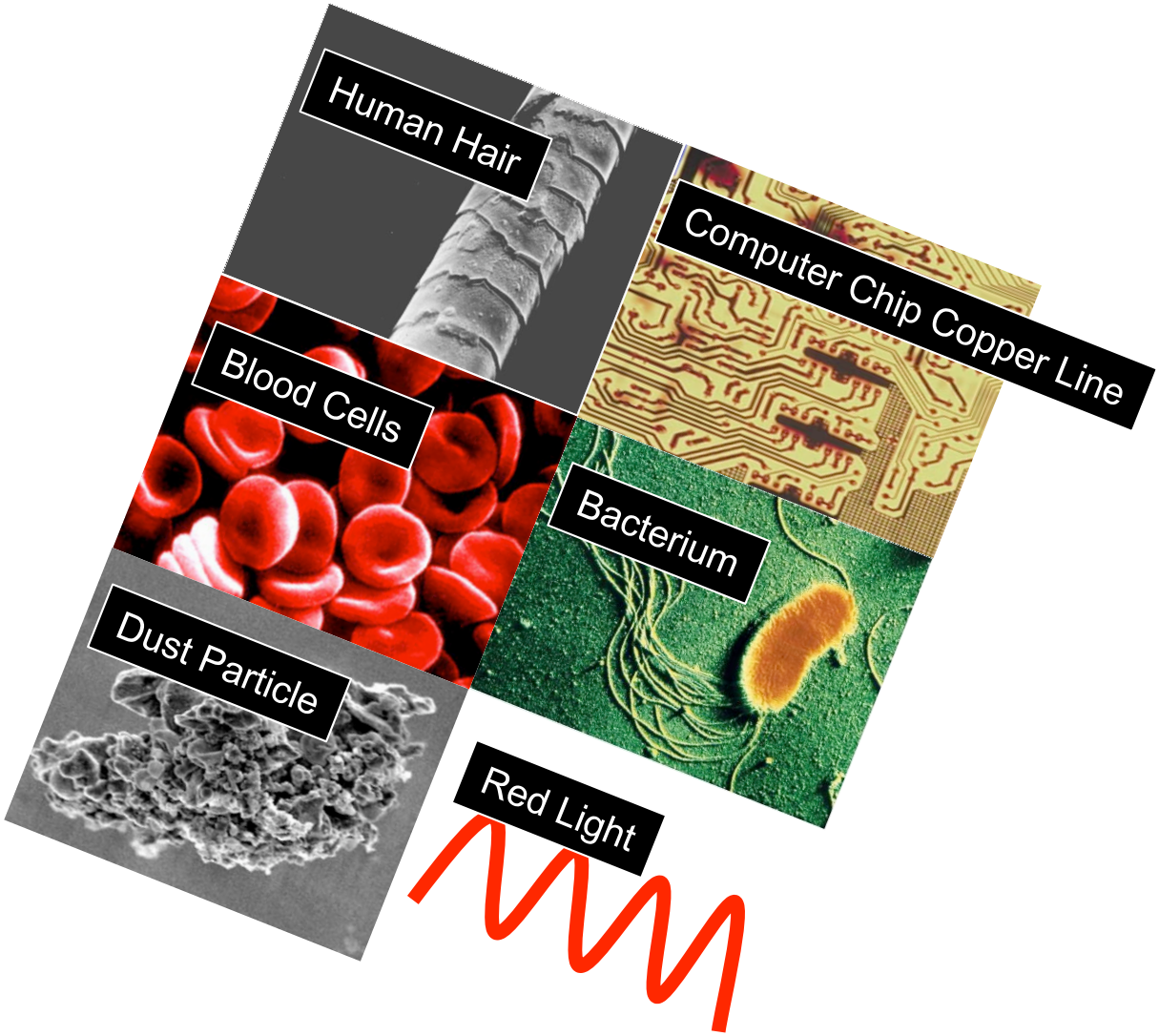


UCR Center for Nanoscale Science and Engineering




Width of a Hair
1 cm

Challenge #1:
Arrange the Objects from Largest to Smallest



Nanometers: How Small?

Nanoscopic

Macroscopic

Microscopic

10^{0} nm

10^{1} nm

10^{2} nm

10^{3} nm

10^{4} nm

10^{5} nm

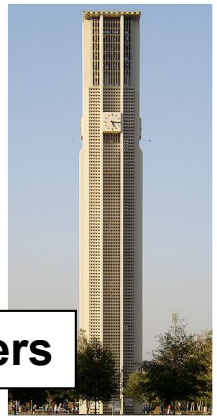
10^{6} nm

10^{7} nm

10^{8} nm

10^{9} nm

10^{10} nm

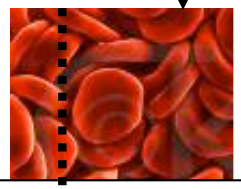


50 meters

1 meter

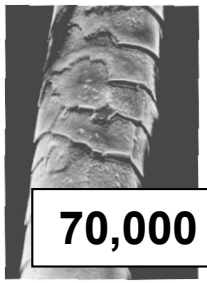
10,000,000 nm

1 cm

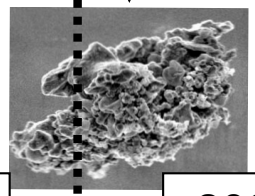


10,000 nm

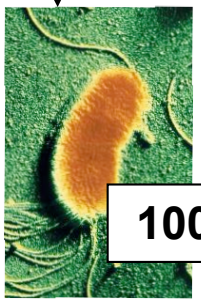
10 μm



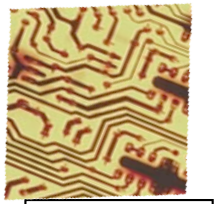
70,000 nm



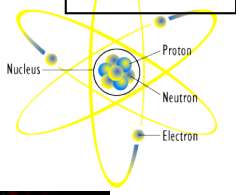
800 nm



1000 nm



65 nm



1 nm

2 nm

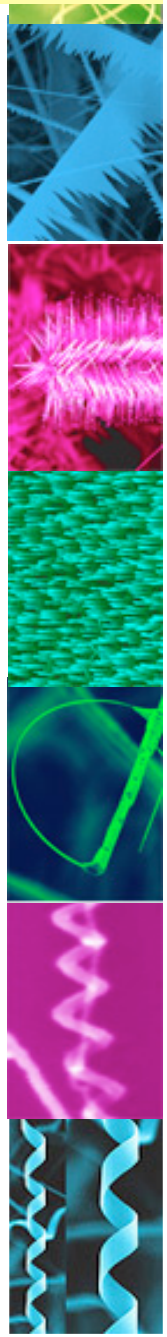
Challenge #2: Let's go big

Instructions:

1. Take a sheet of paper
2. Fold it in half
3. Fold this in half again and keep going…

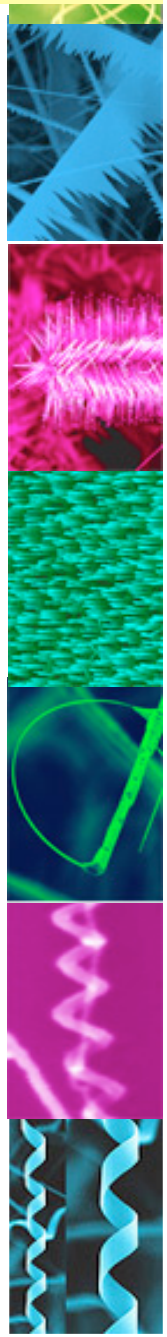
Questions:

1. What is your maximum number of folds?
2. How many sheets of papers are overlapping after 6 folds?
3. How tall is the stack of paper after 50 folds?



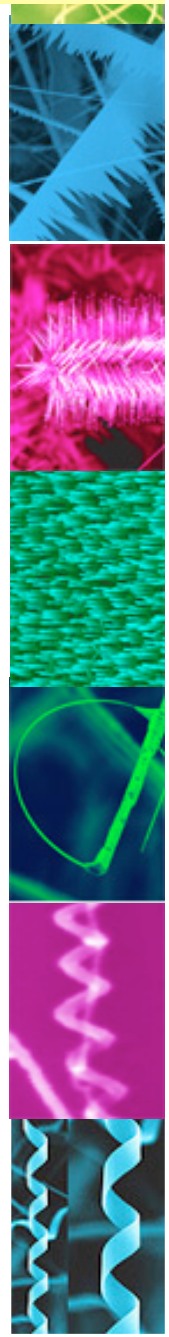
Let's make a data table

# Folds	# Paper	Power rule	Thickness
0			
1			
2			
3			
4			
5			
6			
50			



Let's make a data table

# Folds	# Paper	Power rule	Thickness
0	1	2^0	0.156mm
1	2	2^1	
2	4	2^2	
3	8	2^3	
4	16	2^4	
5	32	2^5	
6	64	2^6	1 cm
50	1.126×10^{15}	2^{50}	



Challenge #2: Let's go big

Answers:

1. What is your maximum number of folds?

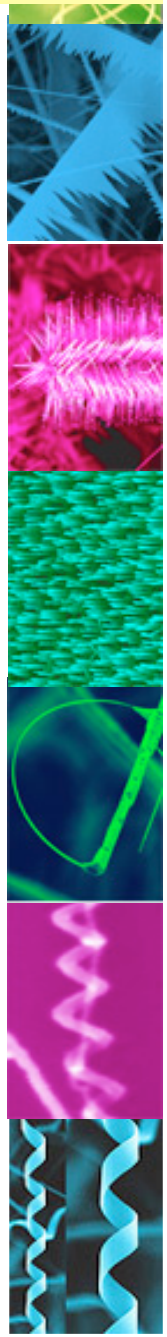
- I got 6

1. How many sheets of papers are overlapping after 6 folds?

- $2^6 = 64$ (~1cm ➔1 sheet of paper ~ 0.156mm)

1. How tall is the stack of paper after 50 folds?

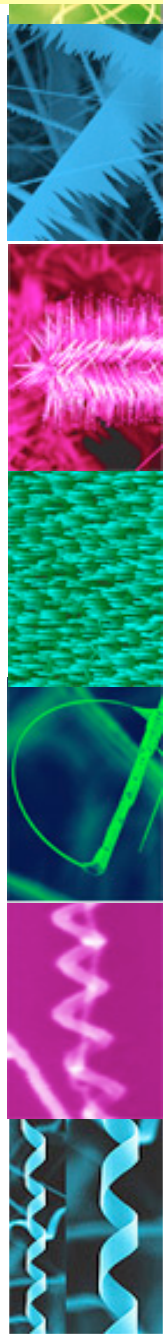
- $2^{50} = 1.126 \times 10^{15}$ (~175×10^6 Km high)
  - Distance Earth-Sun = 149×10^6 Km
  - Distance Earth-Moon ~ 32 folds



Another Example

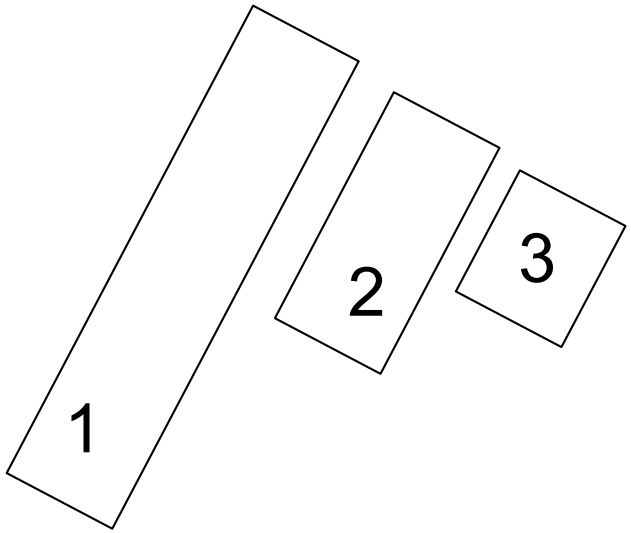
- A house fire started when a (40x40) cm^2 kitchen towel accidentally got placed on top of a burning stove range. A house fire doubles in size every 2 minutes.

Time (min)	Power rule	Burned area (cm^2)
0	2^0	2^0 x 1600 = 1600
2	2^1	2 x 1600 = 2^1 x 1600 = 3200
4	2^2	2 x 3200 = 2^2 x 1600 = 6400
6	2^3	2^3 x 1600 = 12800
8	2^4	25600
10	2^5	51200
12	2^6	102400 (entire kitchen is on fire)
14	2^7	Kitchen and living room are on fire



Challenge #3: On the Cutting-edge.
What does it take to work at the nanoscale.

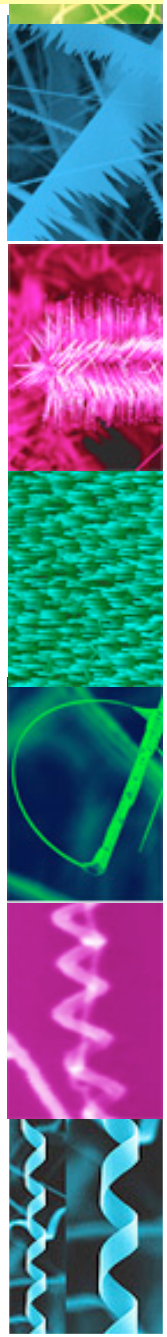
- Materials
  - 1 strip of paper 11” x 1”
  - Scissors



- Questions
  - How many cuts can you make?
  - How many cuts would you need to make to reach the size of an atom (1nm) ?

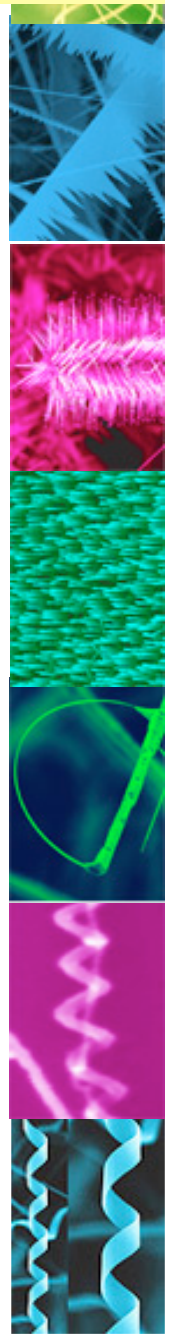
Challenge #3: On the Cutting-edge

Cut #	Fraction of original strip	Power Rule	Length (cm)	Comparison
0	1		28	
1				
2				
3				
4				
5				
6				



Challenge #3: On the Cutting-edge

Cut #	Fraction of original strip	Power Rule	Length (cm)	Comparison
0	1	$1/2^0$	28	My arm
1	1/2	$1/2^1$	14	My hand
2	1/4	$1/2^2$	7	Index finger
3	1/8	$1/2^3$	3.5	
4	1/16	$1/2^4$	1.75	
8	1/256	$1/2^8$	0.11	



Challenge #3: On the Cutting-edge

How many cuts are needed to reach 1nm?

What I know: for 8 cuts I have the following

$$0.109 \text{ cm} = 28 \text{ cm} \times 1/2^{8}$$

What I need to know: after x cuts I have 1nm

$$10^{-7} \text{ cm} = 28 \text{ cm} \times 1/2^{x}$$